HELIX: The High Energy Light Isotope Experiment

Completed Technology Project (2015 - 2020)

Project Introduction

This is the lead proposal for a new suborbital program, HELIX (High-Energy Light Isotope eXperiment), designed to make measurements of the isotopic composition of light cosmic-ray nuclei from ~200 MeV/nuc to ~10 GeV/nuc. Past measurements of this kind have provided profound insights into the nature and origin of cosmic rays, revealing, for instance, information on acceleration and confinement time scales, and exposing some conspicuous discrepancies between solar and cosmic-ray abundances. The most detailed information currently available comes from the ACE/CRIS mission, but is restricted to energies below a few 100 MeV/nuc. HELIX aims at extending this energy range by over an order of magnitude, where, in most cases, no measurements of any kind exist, and where relativistic time dilation affects the apparent lifetime of radioactive clock nuclei. The HELIX measurements will provide essential information for understanding the propagation history of cosmic rays in the galaxy. This is crucial for properly interpreting several intriguing anomalies reported in recent cosmic-ray measurements, pertaining to the energy spectra of protons, helium, and heavier nuclei, and to the anomalous rise in the positron fraction at higher energy. HELIX employs a high-precision magnet spectrometer to provide measurements which are not achievable by any current or planned instrument. The superconducting magnet originally used for the HEAT payload in five successful high-altitude flights will be combined with state-of-the-art detectors to measure the charge, time-of-flight, magnetic rigidity, and velocity of cosmic-ray particles with high precision. The instrumentation includes plastic scintillators, silicon-strip detectors repurposed from Fermilab's CDF detector, a high-performance gas drift chamber, and a ring-imaging Cherenkov counter employing aerogel radiators and silicon photomultipliers. To reduce cost and technical risk, the HELIX program will be structured in two stages. The first stage, which is the subject of this proposal, will focus on the design and construction of the main HELIX instrument, and the measurement of key light isotope ratios from ~200 MeV/n to ~3GeV/n. A future stage 2 will build on this work, incorporating evolutionary enhancements to the instrumentation to extend the energy reach into the challenging ~10 GeV/n range. The stage 1 instrument achieves a maximum detectable rigidity of ~800GV and charge range from Z=1 to Z=10. The high field of the HEAT magnet will make it possible to reach the required mass resolution dm/m = 2.5% over the energy range of concern with very small systematic limitations due to multiple Coulomb scattering in the thin tracker. This is a decisive advantage over the current AMS-02 instrument which employs a permanent magnet with an average field ~7 times smaller than that of HELIX. The primary scientific goals of the full HELIX program are:
- a high-statistics measurement of the 10Be/9Be 'clock ratio' to ~10 GeV/nuc
- a high-statistics measurement of the 3He/4He ratio to ~12GeV/nuc - the first measurements of 22Ne/20Ne above 1 GeV/nuc - the first measurements of 7Li/6Li, and 10B/11B above 1 GeV//nuc A number of secondary goals will also be pursued including the measurement of several other isotopic and elemental abundance ratios and fluxes, as well as the primary Helium flux to

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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

Astrophysics Research and Analysis

Project Management

Program Director:

Michael A Garcia

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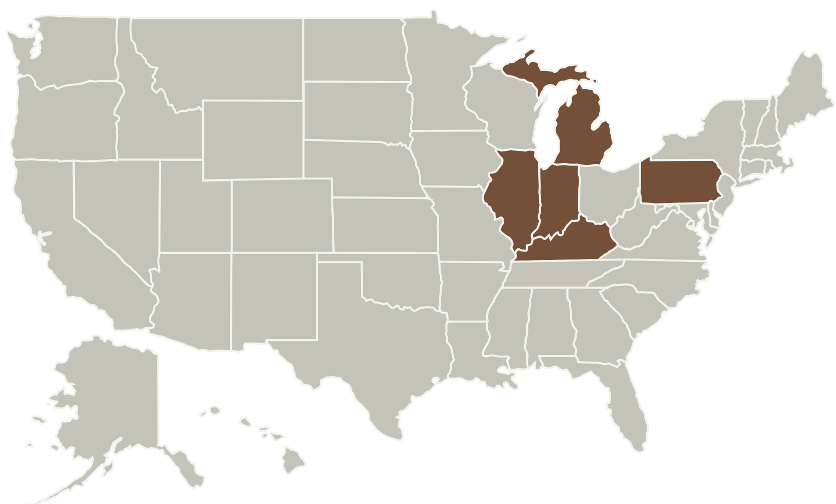
~125 GeV/nuc, where there is currently disagreement between AMS-02 and PAMELA on the shape of the energy spectrum. The proposed work will be conducted by a team of US scientists and engineers with extensive experience in cosmic-ray observations on balloons or in space, and, specifically in magnet spectroscopy, with the SMILI, P-BAR, and HEAT programs. Significant participation from a crew of more than 10 graduate and undergraduate students forms an important educational element of the program.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
University of Chicago	Supporting Organization	Academia	Chicago, Illinois

Primary U.S. Work Locations	
Illinois	Indiana
Kentucky	Michigan
Pennsylvania	

Project Management *(cont.)*

Program Manager:

Dominic J Benford

Principal Investigator:

Scott P Wakely

Co-Investigators:

Jim Musser
Gregory Tarle
Scott Nutter
Dietrich Muller
Stephane Coutu
Nahee Park
Carol Zuiches

Technology Areas

Primary:

- TX08 Sensors and Instruments
  └ TX08.1 Remote Sensing Instruments/Sensors
    └ TX08.1.1 Detectors and Focal Planes

Target Destination

Outside the Solar System